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THE
DESCRIPTION
AND
USE
OF THE
GLOBES,
Celestial and Terrestrial;

With
VARIETY of *EXAMPLES*
For the LEARNER'S EXERCISE:

Intended for the USE of such Persons as
would attain to the KNOWLEDGE of those
INSTRUMENTS;

BUT
Chiefly designed for the INSTRUCTION
of the young GENTLEMEN at the ACADEMY in Philadelphia.

To which is added
RULES for working all the CASES in Plain and
Spherical TRIANGLES without a SCHEME.

By *THEOPHILUS GREW,*
Mathematical Professor.

GERMANTOWN,
Printed by CHRISTOPHER SOWER, 1753.

DESCRIPTION

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A DESCRIPTION

OF THE

Artificial GLOBES,

CELESTIAL and TERRESTRIAL.

A *GLOBE*, or *Sphere*, is a round solid Body, every Part of whose Surface is equally distant from a Point within it, called the Center. Its Genesis may be easily conceived thus, If the Diameter of a Semicircle remain unmoved, while the Semicircle is turned about, till it return to the same Place whence its Motion began, the Semicircle will by this Motion describe a *Sphere*, or *Globe*.

The *Terrestrial Globe* has all the Parts of the *Earth* and *Sea* drawn or delineated on its Surface, like as on a *Map*, and placed in their natural Order and Situation.

The *Celestial Globe* has painted upon the Superficies thereof the Images of the *Constellations* and the *Fixed Stars*, in their due Positions, being an artificial Representation of the *Heavens*.

The *Use* of these *Globes* is to shew the Order and Extent of the *Earth's* Surface, the Order

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and Situation of the *Fixed Stars*, and to resolve *Geographical* and *Astronomical* Problems.

The *Appurtenances* belonging to these *Globes*, are, the *brass Meridian*, *Horizon* or wooden Frame, the *Quadrant* of *Altitude*, and *Hour-Circle*.

The *brass Meridian* is the Ring in which the *Globe* hangeth, and turneth upon its *Axis*; 'tis divided into four *Nineties*, or 360 *Degrees*, counted both Ways from the *Equinoctial*. Its Use is to shew the *Declination* of the *Sun* and *Stars* on the *Celestial Globe*, and the *Latitude* of Places on the *Terrestrial Globe*, either *North* or *South*.

The *Horizon* is a broad wooden Circle, encompassing the *Globe*, having two Knotches on the *North* and *South* Parts of it, to receive the *brass Meridian*. On this wooden Frame, or *Horizon*, are drawn several concentric Circles, the innermost of which is a Circle divided into four *Nineties*, counted both Ways from the *East* and *West* Points, with 10, 20, 30, &c. to 90 *Degrees*, at the *brass Meridian*. Next to this is a Circle, divided into thirty-two equal Parts, to which are set the Names of the Points of the *Mariner's Compass*. Next to this is a Circle, divided into twelve equal Parts, to which are set the Names and Characters of the twelve *Signs* of the *Ecliptic*; and each of these are again divided into thirty equal Parts, or *Degrees*. And without these is another Circle, divided into three-hundred and sixty-five Parts, which are the Days of the Year. The

A DESCRIPTION of the GLOBES. 5

two outermost Circles shew the *Sun's* Place any Day of the Year, and the two innermost shew the *Azimuth* and *Amplitude* of the *Sun* or *Stars*, and the Point of the *Compass* they rise or set upon, as also the true Bearing of one Place on the Earth from another.

The *Quadrant* of *Altitude* is a thin brass Plate, divided into 90 Degrees, at one End of which is rivetted a brass Nut, with a Screw, to screw it fast to any Degree of the *Meridian*, though when it is used it is most commonly fixed to the highest Point, or Zenith. The Use of this *Quadrant* is to find the Bearing and Distance of any two Places on the *Terrestrial Globe*; and on the *Celestial Globe* it is useful for finding the Bearing and Distance of any two *Stars*, their *Altitudes*, *Amplitudes*, and *Azimuths*, and for describing *Almicantars*.

The *Hour-Circle* is a flat Ring of Brass, divided into twice twelve Hours, to which belongs an *Index*, with a Hole at one End, to put on the *Axis* of the *Globe*. This Plate, with the *Index*, is useful in solving all those Problems where the Time of the Day or Night is concerned.

The *Axis* of the *Globe* is an imaginary Line, supposed to pass through its Center, the extreme Points of which are called one the *North Pole*, and the other the *South Pole*. These *Poles* are represented by the two Wires about which the *Globe* turneth.

Besides this outward Furniture, already described, there are drawn on the Surface of the

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Globes divers other *Circles*, both *Great* and *Small*.

The *Great Circles* are the *Equator* or *Equinoctial*, the *Ecliptic*, *Meridians*, and *Circles of Longitude*.

The *Small Circles* are the *Parallels of Latitude*, *Parallels of Declination*, the two *Tropics*, and *Polar Circles*.

The *Equator* on the *Terrestrial Globe* is a great Circle, equidistant from either *Pole*, it divides the *Globe* into two equal Parts, called the Northern and Southern *Hemispheres*. This Circle is divided into 360 Degrees, numbered both Ways, that is, easterly and westerly, to 180 Degrees from the *First Meridian*, which is the Meridian of *London* in our new *Globes*. The Use of this Circle is to determine the *Longitude* of any Place on the *Earth's Surface*.

The *Equinoctial* on the *Celestial Globe* is the same with the *Equator* on the *Terrestrial Globe*; it divides the *Globe* into two equal Parts, and lieth equally between its *Poles*, it passeth through the East and West Points of the *Horizon*; so that whenever the *Sun* comes to this Circle, the Days and Nights are equal all over the *Earth*. This Circle, as well as the *Equator*, is divided into 360 Degrees; but these are numbered from the *Equinoctial Point Aries*, with 10, 20, 30, &c. all round the *Globe*, to 360.

The *Ecliptic* is a great Circle, cutting the *Equator* or *Equinoctial* into two equal Parts, and the Points of Intersection are called the *Equinoctial Points*, or *Aries* and *Libra*. This Circle

is

A DESCRIPTION of the GLOBES. 7

is divided into twelve equal Parts, called *Signs*, and each *Sign* is divided into 30 Degrees, numbered with 10, 20, 30; the Names and Characters of these *Signs* are as follows,

<i>Aries</i> - -	♈	<i>Libra</i> - -	♎
<i>Taurus</i> - -	♉	<i>Scorpio</i> - -	♏
<i>Gemini</i> - -	♊	<i>Sagittarius</i> - -	♐
<i>Cancer</i> - -	♋	<i>Capricorn</i> - -	♑
<i>Leo</i> - - -	♌	<i>Aquarius</i> - -	♒
<i>Virgo</i> - -	♍	<i>Pisces</i> - -	♓

The *Ecliptic Circle* is called the *Way of the Sun*; but in the *new Astronomy* it is that Circle which the Center of the *Earth* describes in its annual Revolution.

The *Poles* of the *Ecliptic* are two Points, distant from the *Ecliptic Line* 90 Degrees on either Side; and are distant from the *Poles* of the *World* 23° 30'. Or rather 23° 29'.

The *Meridians* are great Circles, crossing one another in the *Poles* of the *World*, and cutting the *Equinoctial* at right Angles. These Circles are supposed to pass through every Degree and Minute of the *Equator* or *Equinoctial*, and on the *Terrestrial Globe* they are usually drawn through every 15 Degrees of the *Equator*. One of these is called the *First Meridian*, to the eastward or westward of which, *Longitude* on the *Earth* is computed.

The *Colures* are two *Meridians*, drawn on the *Celestial Globe*, cutting each other at right Angles, one of which passeth through the *Equinoctial Points Aries and Libra*, called the

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Equinoctial Colure, and is numbered from the *Equinoctial* towards either *Pole* with 10, 20, 30, &c. to 90 Degrees. The other passeth through the *Solstitial Points Cancer* and *Capricorn*, and is called the *Solstitial Colure*, it is numbered both Ways from the *Ecliptic* towards the *Poles* thereof, with 10, 20, 30, &c. to 90 Degrees.

The *Circles of Longitude* are great Circles, drawn on the *Celestial Globe*, intersecting each other in the *Poles* of the *Ecliptic*, and therefore cut the *Ecliptic* at right Angles. These, with the *Solstitial Colure*, are of Use to determine the *Longitude* and *Latitude* of the *Stars*, and, like the *Meridians*, are infinite in Number, though on the *Globe* there are usually drawn but six of them, passing through the *Ecliptic* at the Beginning of each *Sign*, the rest being supplied by the *Quadrant of Altitude*.

Parallels of Latitude are small Circles, drawn on the *Terrestrial Globe* parallel to the *Equator*, but on the *Celestial Globe* they are drawn, or supposed to be drawn, parallel to the *Ecliptic*. These are also in Number infinite; but to avoid Confusion, they are only drawn on the *Terrestrial Globe* to every 10 Degrees of the *brass Meridian*, on each Side of the *Equator*, and on the *Celestial Globe* they are represented by the Divisions of the *Quadrant of Altitude* in its Motion round the *Globe*, when it is screwed over the *Pole* of the *Ecliptic*.

Parallels of Declination are small Circles, parallel to the *Equinoctial* on the *Celestial Globe*,
and

and answer to the Parallels of *Latitude* on the *Terrestrial Globe*. These are not usually drawn on the *Celestial Globe*, but are supposed to pass under every Degree and Minute of the *brafs Meridian*.

The *Tropics* are two small Circles, parallel to the *Equinoctial*, one on each Side, and distant therefrom $23^{\circ} 29'$; that on the North Side is called the *Tropic of Cancer*, it passing through the Beginning of that *Sign*; the other, on the South Side, is called the *Tropic of Capricorn*, and passeth through the Beginning of that *Sign*. Between these two Circles the *Sun's* Center is always found; and when the *Sun* comes to the *Tropic of Cancer*, it makes the longest Day in the Northern *Hemisphere*, as, when the *Sun* arrives at the *Tropic of Capricorn*, it makes the shortest Day; but contrarywise in the Southern *Hemisphere*.

The *Polar Circles* are two small Circles, drawn on each *Globe* parallel to the *Equinoctial*, and distant from it $66^{\circ} 31'$, and from the *Poles* of the *World* $23^{\circ} 29'$. That towards the *North Pole* is called the *Arctic Circle*, and the other towards the *South Pole* is called the *Ant-arctic Circle*.

On the *Celestial Globe* there are drawn two Circles parallel to the *Ecliptic*, one on each Side, distant from it about 8 Degrees; the Space in the *Heavens* contained between these two Lines, or Parallels of *Latitude*, is called the *Zodiac*, in which the *Planets* make their *Revolutions*.

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The *Tropics* and *Polar Circles* divide the Surface of the *Terrestrial Globe* into five Parts, called *Zones*.

All that Space between the *Tropics* is called the *Torrid Zone*; those two equal Spaces between the *Tropics* and *Polar Circles* are called *Temperate Zones*, and those equal Spaces contained within the *Arctic* and *Antarctic Circles* are called the *Frigid Zones*.

In fixing the *Globes* you must mind that the graduated Side of the *brass Meridian* face towards the East Side of the *Horizon*; and the Line of 12 and 12 on the *Hour-Circle* must lie on the graduated Edge of the *brass Meridian*.

Besides this Description of the *Globes*, it will be necessary to understand the following *Definitions*, as pertinent thereto.

The *Poles* of the *Horizon* are two Points, called the *Zenith* and *Nadir*. The *Zenith* is the Point right over our Heads, and the *Nadir* is a Point in the *Heavens* right under us, being diametrically opposite to the *Zenith*; so that a right Line drawn from one to the other passeth through the *Earth's Center*.

Azimuths are great Circles, perpendicular to the *Horizon*, passing through the *Zenith* and *Nadir*; and that which passeth through the East and West Points of the *Horizon*, is called the *Prime Vertical Circle*, or East and West *Azimuth*.

Almacantars, or *Parallels of Altitude*, are small Circles, parallel to the *Horizon*; these are easily represented on the *Globe* by the Degrees of the
Quadrant

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Quadrant of Altitude being turned about, the *Quadrant* first screwed to the *Zenith*.

Latitude of any Place on the *Earth's* Surface, is its Distance from the *Equator*; or it is' an Arch of the *Meridian* passing over the said Place, and contained between the said Place and the *Equator*, which is always equal to the Height of the *Pole*.

Longitude of any Place on the *Earth's* Surface is an Arch of the *Equator*, contained between the *Meridian* of the said Place and that *Meridian* from which *Longitude* is computed. Whence the Difference of *Longitude* between two Places is an Arch of the *Equator* contained between the *Meridians* of each Place.

Declination of the *Sun* or of a *Star* is its Distance from the *Equinoctial*, and is measured by an Arch of the *Meridian*, contained between the Center of the *Sun* or *Star* and the *Equinoctial*.

Right Ascension of the *Sun* or *Star*, is an Arch of the *Equinoctial*, contained between the *Meridian* of the *Sun* or *Star* and the *Equinoctial* Point *Aries*. Or it is that Degree and Minute of the *Equinoctial* (counted from the Beginning of *Aries*) that cometh to the *Meridian* with the *Sun* or *Star*. Or, in a right *Sphere*, it is the Degree and Minute of the *Equinoctial* (counted from the Beginning of *Aries*) that riseth with the Center of the *Sun* or *Star*.

Longitude of the *Sun* is an Arch of the *Ecliptic* Circle, contained between the Center of the *Sun* and the Beginning of *Aries*, counted according to the Order of the Signs.

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Longitude of a *Star* is an Arch of the *Ecliptic*, intercepted between the Beginning of *Aries* and that Circle of Longitude that passeth through the Center of the *Star*.

Sometimes the Longitude of the *Sun* or *Star* is reckoned from the nearest Equinoctial Point; and in this Case the *Longitude* will be always less than 180 Degrees.

Latitude of a *Star*, is an Arch of a Circle of *Longitude* passing through the Center of the said *Star*, and intercepted between the *Star* and the *Ecliptic* Line; or it is the *Star's* Distance from the *Ecliptic*, counted towards the *Pole* thereof.

Altitude of the *Sun* or *Star*, is an Arch of the *Azimuth* Circle, contained between the Center of the *Sun* or *Star* and the *Horizon*, counted from the *Horizon* towards the *Zenith*. And the *Depression* is an Arch of the same Circle, counted from the *Horizon* towards the *Nadir*.

And that Arch of the *Azimuth* Circle intercepted between the *Sun* or *Star* and the *Zenith*, is called the *Zenith* Distance; which, together with the *Altitude*, is always equal to a *Quadrant*, or 90 Degrees.

The *Meridian* of a Place, is that *Meridian* which passeth through the *Zenith* and *Nadir*, and the North and South Points of the *Horizon*, to which when the *Sun* cometh it is Noon-Day, and the *Sun* or *Stars* being there, they are said to be on the *Meridian*.

Azimuth of the *Sun* or *Star*, is an Arch of the *Horizon*, contained between the *Meridian* of the
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the Place and the *Vertical Circle* that the Center of the *Sun* or *Star* is in, and is accounted from the *Meridian* of the Place towards the *East* and *West*.

Amplitude of the *Sun* or *Stars*, is an Arch of the *Horizon*, intercepted between the *East* and *West* Points thereof, and the Center of the *Sun* or *Stars* at their Rising and Setting, and is counted from the *East* and *West* towards the *North* and *South*.

Oblique Ascension, is an Arch of the *Equinoctial*, contained between the Beginning of *Aries* and that Point of the *Equinoctial* that riseth with the Center of the *Sun* or *Star* in an oblique *Sphere*; and that Part of the *Equinoctial* that setteth with the Center of the *Sun* or *Star*, or any Point in the Heavens, in an oblique *Sphere*, is called the *Oblique Descension*.

Ascensional Difference, is an Arch of the *Equinoctial*, intercepted between the Points of right *Ascension* and oblique *Ascension*; or it is that Space of Time the *Sun* rises or sets before and after Six o'Clock.

The *Complement* of any Arch, is what that Arch wants of 90 Degrees; so the *Complement* of the *Latitude* of a Place is its Distance from the *Pole* of the *World*, or the Height of the *Equinoctial*; the *Complement* of the *Altitude* of the *Sun* or *Stars* is their Distance from the *Zenith*; the *Complement* of the *Declination* of any Point in the *Heavens*, is the Distance of that Point from the nearest *Pole*, &c.

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The *Terrestrial Globe*, according to its various Positions, may be considered as *Direct*, *Parallel*, and *Oblique*.

The *Direct*, or *Right Sphere*, is when the *Poles* of the *World* lie in the North and South Points of the *Horizon*; which Position answers to those Inhabitants under the *Equinoctial*. For here the *Equinoctial* passeth through the *Zenith*, and this Circle, with all the *Parallels* of *Declination*, cut the *Horizon* at right Angles, whence the Days and Nights here are always equal, and in Length Twelve Hours; and not only the *Sun*, but all the heavenly Bodies are twelve Hours above the *Horizon*, and twelve Hours underneath.

A *Parallel Sphere*, is when the *Equator* coincides with the *Horizon*, and the *Poles* of the *World* become the *Zenith* and *Nadir*. This is the very Case with those Inhabitants (if any) who live under the *Poles* of the *World*; here the *Parallels* of *Declination* are all parallel to the *Horizon*, and the *Sun* only rises and sets when he passeth the *Equinoctial Points*; so that here is but one Day and one Night in the whole *Year*, each in Length six Months: And notwithstanding the Length of this Day, the *Sun's* greatest *Altitude* is no more than 23 Degrees 29 Minutes, the Quantity of his greatest *Declination*.

The *Stars* in either *Hemisphere* describe Circles parallel to the *Horizon* in their diurnal Motion; those in the upper *Hemisphere* being always visible,

ible, and those in the lower *Hemisphere* always invisible.

The *Oblique Sphere*, is when the *Pole* of the *World* is above the *Horizon*, which agrees with all the Parts of the *Earth* betwixt the *Equator* and the *Poles*. The Consequence of this Position is, that the *Equinoctial*, with all its *Parallels of Declination*, whose Distance from the *Pole* exceeds its *Altitude*, cut the *Horizon* at oblique Angles, and the Angle made by the *Horizon* and *Equinoctial* is every where equal to the Distance of the *Pole* from the *Zenith*, or the Complement of the *Latitude*; the *Horizon* cuts these *Parallels of Declination* unequally, whence the diurnal and nocturnal Arches are of unequal Lengths, and consequently the Days and Nights are so likewise, unless twice a Year, when the *Sun* is in the *Equinoctial*. Moreover, Those *Parallels of Declination*, whose Distance from the *Pole* is less than the *Poles* Height, are not cut by the *Horizon* in our View; whence it is, that all those Stars whose *Declination* is greater than the Complement of the *Latitude*, never rise nor set, but are always in Sight.

A *Constellation* in the *Heavens*, is a Company of *Fixed Stars*, to which the Ancients appropriated a Name conformable (as they imagined) to the Thing they represented. They are in Number forty-eight; twenty-three in the Northern and twenty-five in the Southern *Hemisphere*.

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I observed before, that the *Ecliptic* is divided into twelve *Signs*, these *Signs* received their Names from the twelve *Constellations* of the *Zodiac*: For formerly the *Equinoctial Point Aries* was between the *Constellations Pisces* and *Aries*, and the *Equinoctial Point Libra* between the *Constellations Virgo* and *Libra*; but by reason of the *Precession* of the *Equinox*, the twelve *Divisions* of the *Ecliptic* are removed out of their ancient Places, notwithstanding which they still retain the same Names. And hence it is, that the *Sun*, when in *Aries*, moves amongst the *Stars* in the *Constellation Pisces*, and when he is in *Taurus*, he appears in the *Constellation Aries*, &c.

By comparing the *Observations* of the *Ancients* with those of the *Moderns*, it is found, that the *Distance* of the *Fixed Stars* from the *Equinoctial Point Aries* is ever increasing, and this *Motion* is called the *Procession* of the *Equinox*, and is about one *Degree* in seventy-two *Years*.

THE USE OF THE Terrestrial GLOBE.

P R O B L E M I.

How to find the Latitude of any Place.

BRING the Place proposed to the graduated Side of the brass *Meridian*, and the Degree of the *Meridian* right over it will shew the *Latitude* of the said Place, either North or South. Thus the *Latitude* of

<i>Philadelphia</i> , is	- -	40° 0' North
<i>London</i>	- - - -	51 32 North
<i>Boston</i>	- - - -	42 25 North
<i>Barbadoes</i>	- - -	13 0 North
<i>Cape of Good Hope</i>	-	34 25 South
<i>Fort St. George</i>	- -	13 8 North
<i>Lima in Peru</i>	- -	12 30 South
<i>Cape Horn</i>	- - -	58 0 South

P R O B. II.

How to find the Longitude of any Place.

Bring the given Place to the graduated Side of the brass *Meridian*, and keeping the *Globe* still, look what Degree of the *Equinoctial* is cut
B by

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By the brass *Meridian*, and that shall be the *Longitude*, reckoned easterly or westerly from the *first Meridian*. Thus the *Longitude* of

<i>Philadelphia</i> , is	- -	75	Degrees West
<i>London</i>	- - - -	0	
<i>Boston</i>	- - - -	71	West
<i>Barbadoes</i>	- - -	59	West
<i>Cape of Good Hope</i>		27	East
<i>Fort St. George</i>	- -	92	East
<i>Lima in Peru</i>	- -	73	West
<i>Cape Horn</i>	- -	80	West

P R O B. III.

How to find the Distance between any two Places.

Lay the graduated Edge of the *Quadrant* of *Altitude* to both the given Places, so as the Beginning of the Degrees shall lie upon one of them; then the Degree of the *Quadrant* over the other Place, shall shew their Distance. Whence the Distance from *Philadelphia* to

<i>London</i> will be found	50	Degrees
<i>Rome</i> - - - - -	62	Deg.
<i>Madeira</i> - - - - -	44	Deg.
<i>Cape Verde</i> - - - - -	54	Deg.
<i>Barbadoes</i> - - - - -	29	Deg.
<i>Panama and Mexico</i> -	32	Deg.
<i>Gulf of California</i> - -	40	Degrees, &c.

If the Distance of the two given Places be more than a *Quadrant*, you must measure it at twice, or else at once by a *Semicircle*. Thus the

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the Distance from *Philadelphia* to the *Cape of Good Hope* will be found about 112 Degrees.

P R O B. IV.

Being at Sea, and knowing what Latitude and Longitude your Ship is in, how to find that very Place on the Surface of the Globe.

Count the given *Longitude* on the *Equinoctial*, eastward or westward from the *first Meridian*, as the Case requires, and bring that Degree to the graduated Side of the brass *Meridian*. Then look on the *Meridian* for your *Latitude*, either North or South, according on which Side of the *Equator* you are, under which make a Mark for the Place of your *Ship*.

EXAMPLE, Suppose you were in the *Latitude* of 31 Degrees North, and *Longitude* 61 Degrees and a half West; by observing the foregoing Directions, you will find the Place of your *Ship* to lie a little to the Southward of *Bermudas*.

P R O B. V.

How to find the Difference of Time between any two Places on the Earth.

Bring the westernmost of the two given Places to the brass *Meridian*, then set the *Index* of the Hour-Circle to 12; that done, turn the *Globe* westward, until you bring the other Place to the brass *Meridian*, then will the *Index* point out the Difference of Time in the Hour-

B 2,

Circle.

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Circle. Hence, when it is 12 o'Clock at Noon at *Philadelphia*, it will be at

	Ho.	Min.	
<i>London</i> - - -	5	0	Afternoon
<i>Boston</i> - - -	12	16	Aft.
<i>Barbadoes</i> - - -	1	4	Aft.
<i>Cape of Good Hope</i> -	6	48	Aft.
<i>Constantinople</i> - -	6	55	Aft.
<i>Fort St. George</i> -	10	26	Aft.
<i>Lima in Peru</i> -	12	6	Aft.
<i>Quebeck</i> - - -	12	21	Aft.
<i>Mexico</i> - - -	10	11	Morning
<i>Batavia</i> - - -	12	0	at Night.

And, after this manner, the Hour being given in any Place, you may find the Time of the Day or Night in any other Part of the World.

P R O B. VI.

How to rectify the Globe to any Latitude, or given Place.

Bring the Place proposed to the brass *Meridian*, and there keep it, observing at the same time the *Latitude*; then raise or depress the *Pole* until the *Horizon* cuts the same Degree of the *Meridian* under the *Pole* as is the *Latitude* of the Place. If the *Latitude* be North, elevate the North *Pole* just so much as the *Latitude* amounts to; but if the *Latitude* be South, then the South *Pole* must be elevated; and then will the Place given be at the very Top of the *Globe*, that is under the *Zenith*, the *Horizon* of the *Globe* will be the *Horizon* of the Place, the

brass

The USE of the Terrestrial GLOBE. 21

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brass Meridian being set North and South will be the true Meridian of the Place, and the Hour-Circles will be the real Hour-Circles to which the Sun comes at those Times of the Day or Night, &c.

P R O B. VII.

How to find the Sun's Place in the Ecliptic for any given Day in the Year.

Look on the wooden Horizon for the Day of the Month, and right against it on the next Circle stands the Sign and Degree of the Ecliptic the Sun is then in. So the Sun's Place will be found on

January	1,	New Style,	☾	11 Degrees
February	12	- - - -	♊	24 Deg.
March	25	- - - -	♈	5 Deg.
June	- 16	- - - -	♊	25 Deg.
August	29	- - - -	♋	6 Deg.
October	- 3	- - - -	♏	10 Deg.
December	17	- - - -	♐	27 Deg. &c.

P R O B. VIII.

To find those Places on the Globe to which the Sun will be vertical on any given Day.

Find the Sun's Place in the Ecliptic by PROB. VII. then bring that Place to the brass Meridian, and observe the Degree of the Meridian right over the Ecliptic. Then turn the Globe round, and all those Places on the Earth's Surface that pass under the said Degree of the

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Meridian will have the *Sun* in their *Zenith* that Day. Thus, on the 24th of *April* the *Sun's* Place will be found to be four Degrees of *Taurus*. Therefore bring 4 Degrees of *Taurus* to the brass *Meridian*, and you will find over it on the *Meridian* 13 Degrees. Then turning the *Globe* about, you will find the following Places to pass under that Division, to wit, *Barbadoes*, *River Gambia*, *Fort St. George*, *Siam Entrance*, &c. to which Places the *Sun* comes that Day vertical, or in their *Zenith*.

Hence it appears that the *Sun* can never come to the *Zenith* of any Place without the *Tropics*; neither within the *Tropics*, but at such Times as the *Latitude* of the Place and *Declination* of the *Sun* are equal, and the same Way.

P R O B. IX.

On any Day of the Year, and any Time of that Day, in any given Place, to find in what Part of the Globe the Sun will be then in their Zenith.

Find the *Sun's* Place in the *Ecliptic* for the given Time, then bring that Place to the *Meridian*, and mark well the Degree over it; then bring the given Place to the *Meridian*, and keeping the *Globe* still, set the *Index* to the given Hour, then turn the *Globe* about until the *Index* points at 12 at Noon, then that Point of the *Globe* which lieth under the aforesaid Degree of the brass *Meridian*, will have the *Sun* vertical at the given Time.

Thus,

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Thus, at *Philadelphia* *May* the 20th, at two o'Clock in the Afternoon, you will find the *Sun* to be vertical over the City of *Mexico*. And on the 18th Day of *August*, at eleven o'Clock in the Morning, the *Sun* will be in the Zenith at *Barbadoes*. Also the 22d Day of *October*, at half an Hour after Three in the Morning, the *Sun* will be in the Zenith at the North End of *Madagascar*, &c.

P R O B. X.

Any Place being given in the Torrid Zone, or within the Tropics, to find what Days in the Year the Sun will be in their Zenith.

Bring the given Place to the brass *Meridian*, and mark well its *Latitude*; then turn about the *Globe*, and observe what Degrees of the *Ecliptic* pass under the said *Latitude* on the brass *Meridian*, and those Points of the *Ecliptic* will be the *Sun's* Place on the Days required. Then look for these Places of the *Sun* amongst the *Signs* and *Degrees* on the wooden *Horizon*, and right against them in the *Kalendar* stand the Days of the Year.

And thus you will find that the *Sun* comes to the Zenith at

<i>Barbadoes,</i>	<i>April</i>	24	and	<i>August</i>	18
<i>St. Helena,</i>	<i>Nov.</i>	6	and	<i>Febr.</i>	5
<i>Antigoa, -</i>	<i>May</i>	8	and	<i>August</i>	5
<i>Cape Verde,</i>	<i>May</i>	18	and	<i>July</i>	26
<i>Mexico, - -</i>	<i>May</i>	20	and	<i>July</i>	23
<i>St. Thomas,</i>	<i>March</i>	20	and	<i>Sept.</i>	23, &c.

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P R O B. XI.

Any Day of the Year being given, when the Sun is in the first Quarter of the Ecliptic, to find those Places in the Northern Frigid Zone, where the Sun begins to shine constantly for a Day, or a Number of Days, without setting.

First find the Place of the Sun for the given Day on the wooden *Horizon*, then bring that Point of the *Ecliptic* to the *Meridian*, and see what Degree of the *Meridian* is right over it; then count so many Degrees on the brass *Meridian* from the *Pole* towards the *Equator*, and where that Reckoning ends make a Mark: Then turn the *Globe* round, and all those Places that pass under the said Mark on the brass *Meridian*, shall be the Places required.

Thus we shall find that the Sun rises in this manner on May 14 at the *North Cape*, and on April 26 at *Cape Lookout*.

P R O B. XII.

A Place being given in the North Frigid Zone, to find how long Time the Sun doth constantly shine there, and how long he is absent; also the Days when he first appears and disappears.

Rectify the *Globe* to the *Latitude*, then turn the *Globe* about, and see what Degrees in the first and second Quarters of the *Ecliptic* are cut by the North Point of the *Horizon*. The first is the Sun's Place when he begins to shine continually, and the second is his Place when he returns

returns again to the *Horizon*. Then look on the wooden Frame, and observe what Days of the Year answer to those Points of the *Ecliptic*, and the Number of Days intercepted will shew how long the *Sun* will continue in the given Place above the *Horizon*, and the Time of his Absence will be nearly equal to this.

Again, Turn the *Globe* about until the fourth Quarter of the *Ecliptic* is cut by the *Horizon* in the South, and that Point of the *Ecliptic* shall be the *Sun's* Place when he first rises after his long Absence, and the Day answering thereto on the wooden *Horizon*, is the Day when the *Sun* begins first to appear.

Again, Turn the *Globe* until the *Horizon* intersect the third Quarter of the *Ecliptic* in the South Point, and the Point of Intersection will be the Place of the *Sun* when he begins totally to disappear, the Day corresponding thereto will be found on the wooden Frame.

EXAMPLE, Let the Place proposed be the *North Cape* in the Latitude of 71 Deg. 25 Min.

By the foregoing Rules it will be found that the *Sun* begins to shine continually in that Latitude the 14th of *May*, and continues above the *Horizon* until the 30th of *July*, which is seventy-seven Days. Also the *Sun* begins to be totally absent on the 15th of *November*, and continues so until the 27th of *January*, when he rises again.

In like manner, at *Cape Lookout*, it will be found that the *Sun* rises there on the 25th of *April*, and sets not again until the 4th of *August*

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gust. That on the 28th of *October* the *Sun* goes down, and rises no more until the 13th of *February*.

P R O B. XIII.

How to find those Places in the Frigid Zone where the Sun shall shine a certain Number of Days without setting.

Count half the Number of Days on the *Ecliptic*, as so many Degrees, reckoning from the Beginning of *Cancer*, and where the Reckoning ends bring that Point to the brass *Meridian*, and observe the Degree of the *Meridian* over it; for so many Degrees as this Point is distant from the *Equator*, so many you must count on the *Meridian* from the *North Pole* towards the *Equator*, and mark the End of this Reckoning. Then turn about the *Globe*, and all those Places that pass under this Mark are the Places desired.

If you operate towards the *South*, count half the Number of Days, as so many Degrees, from the Beginning of *Capricorn*; and in either Case, if half the Number of Days amount to 30, count but 29 Degrees from *Cancer* or *Capricorn*; if 60 Days, but 58 Degrees, &c.

Thus, if it were required to find what Part of the *Frigid Zone* the *Sun* will shine the Length of 100 Days constantly without setting, it will be found to be at *Cherry Island*, between the *North Cape* and *Point Lookout*, and all other Places in that Parallel.

P R O B.

PROB. XIV.

The Day of the Year and Time of the Day being given, to find those Places on the Earth where the Sun is rising; those Places where he is setting; those Places where it is Noonday; those Places where it is Midnight; that Part of the Earth which is illuminated, and that Part which is then in Darkness.

By PROB. IX. find that Part of the Earth where the Sun is vertical at the given Time; the same being brought to the *Meridian*, let the *Globe* be rectified to its *Latitude*. Then,

Those Places in the western Semicircle of the *Horizon* have the Sun a-rising.

Those Places in the eastern Semicircle of the *Horizon* have the Sun a-going down.

Those Places under the upper Semicircle of the brass *Meridian* have *Midday*.

Those Places under the lower Semicircle of the brass *Meridian* have *Midnight*.

Those Places above the *Horizon* are illuminated, and those Places under the *Horizon* are in Darkness; except those that are less than 18 Degrees below the *Horizon*, which have *Twilight*.

And as many Degrees as any Place is above or under the *Horizon*, just so many Degrees they have the Sun elevated or depressed.

Thus, the 20th of May, at Two o'Clock in the Afternoon at *Philadelphia*, the Sun will be rising in the Great South Sea, near the Land of *Jesso*, *New Zealand*, &c.

He

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He will be setting to those in the Western Parts of *Moscovy*, in the *Baltic Sea*, in *Germany*, *Italy*, *Island Ascension*, &c.

It will be Midday at *Mexico*, *New North Wales*, &c. and Midnight at *Cape Comerine*, *Fort St. George*, &c.

The Parts of the Earth illuminated will be all *America*, the western Parts of *Europe* and *Africa*, the *Great South Sea*, and *Atlantic Ocean*.

And the obscured Parts of the *Globe* will be all *Asia*, the eastern Parts of *Europe*, and almost all *Africa*, *New Holland*, the *Indian Sea*, and Part of the *Southern Ocean*.

P R O B. XV.

The Time of a Lunar Eclipse being known, to find all those Parts of the Globe where it will be visible.

By PROB. IX. find that Part of the *Globe* which will have the *Sun* in the *Zenith*, at the given Time; and then bring the opposite Point, or *Antipodes*, to the *Zenith*: And the *Eclipse* will be visible to all that Part of the *Globe* above the *Horizon*.

Thus, the *Eclipse* of the *Moon*, which will happen the 7th of *April* 1754, will be visible all over *America*, the *Great South Sea*, and Part of the *Atlantic Ocean*.

And the *Eclipse* of the *Moon* which will happen the first of *October* the same Year, will be visible in all *America*, except the East Side of *Brazile*. In Part of the *Atlantic Ocean*, the *Pacific Ocean*, Part of *Asia*, and the *Asiatic Islands*.

P R O B.

P R O B. XVI.

1 Place being given on the Globe, to find the Bearing of any other Place.

Bring the given Place to the Zenith, and here screw the *Quadrant* of *Altitude*, then bring the graduated Edge of the *Quadrant* to that Place whose Bearing you want to know, and the *Quadrant* will cut the *Horizon* in the Point of the Compass. And thus it will be found that *London* bears from *Philadelphia* about North 50 Degrees East; and the following Places, to wit,

<i>Stockholm</i>	N. 36 Deg.	E.
<i>Madrid</i> -	N. 65 Deg.	E.
<i>St. Helena</i>	S. 64 Deg.	E.
<i>Panama</i> -	S. 10 Deg.	W.
<i>Mexico</i> - -	S. W. by	W.

It is to be observed, that these Bearings are only the true Situations of those Places in respect to *Philadelphia*, or the Angles of Position; and not the Courses to be steered by the Compass: For it is well known that the Rhumb or Course from *Philadelphia* to *London* is E. N. E. $\frac{3}{4}$ E. and better; the Rhumb Line not being a great Circle of the *Sphere*, but a spiral Line.

THE USE OF THE Celestial GLOBE.

PROBLEM I.

How to find the Sun's Right Ascension and Declination, for any given Day.

FIRST find the *Sun's Place* in the *Ecliptic*, by PROB. VII. of the Use of the *Terrestrial Globe*.

Bring the Place of the *Sun* to the graduated Side of the brass *Meridian*, and there keep it.

The Degree of the *Equinoctial* cut by the brass *Meridian*, is the *Sun's Right Ascension*.

And the Degree of the *Meridian* cut by the *Ecliptic*, is the *Sun's Declination*.

Thus, the 15th of *April*, I find the *Sun's Place* to be 25 Degrees and a half of *Aries*, and the *Sun's Right Ascension* 23 Degrees 37 Minutes, and the *Declination* 9 Degrees 52 Minutes North Ascending.

More

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More EXAMPLES for Practice.

		R. Ascen. Dec.			
		deg. min.	deg. min.	deg. min.	
Sun's Place	♈	20 0 -	47 32 -	17 46	No. Asc.
	♏	5 15 -	63 19 -	21 13	No. Asc.
	♍	17 0 -	108 26 -	22 24	No. Def.
	♌	10 30 -	132 57 -	17 38	No. Def.
	♎	14 20 -	165 34 -	6 10	No. Def.
	♊	28 45 -	206 43 -	11 2	So. Asc.
	♍	12 10 -	219 39 -	15 30	So. Asc.
	♈	17 0 -	255 52 -	22 50	So. Asc.
	♏	20 30 -	292 10 -	21 55	So. Def.
	♍	3 12 -	305 23 -	19 28	So. Def.
	♌	22 0 -	352 39 -	3 10	So. Def.

P R O B. II.

The Sun's Right Ascension being given, to find his Place in the Ecliptic, and his Declination.

Count the Right Ascension of the *Sun* on the *Equinoctial*, and bring that Point to the brass *Meridian*.

Then see what Degree of the *Ecliptic* is cut by the brass *Meridian*, and that is the *Sun's* Place.

Also look what Degree of the *Meridian* is cut by the *Ecliptic*, and that is his *Declination*.

Thus, if the *Right Ascension* of the *Sun* be 25 Degrees, his Place in the *Ecliptic* will be found to be ♈ 26 Degrees 57 Minutes, and his *Declination* 10 Degrees 24 Minutes North Ascending.

More

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MORE EXAMPLES.

		Sun's Place.		Dec.	
		deg.	min.	deg.	min.
R. Asc.	120 Deg. -	☿	27 54	-	20 37 No. def.
	216 Deg. -	♈	8 23	-	14 20 So. asc.
	342 Deg. -	♏	10 30	-	7 39 So. def.

PROB. III.

The Declination of the Sun being given, to find his Place in the Ecliptic, and his Right Ascension.

Move the *Globe* about until the *Ecliptic* Line pass just under the Degree of *Declination* on the brass *Meridian*, and there let the *Globe* rest.

Then the Degree of the *Ecliptic* lying under the brass *Meridian*, shall shew the *Sun's Place*.

And the Degree of the *Equinoctial* lying under the *Meridian* shall be the *Sun's Right Ascension*.

EXAMPLES.

		Sun's Place.		R. Asc.	
		deg.	min.	deg.	min.
The Sun's Dec.	13 deg. No. asc. -	♈	4 22	-	32 6
	22 deg. No. def. -	♏	19 56	-	111 35
	7 deg. So. asc. -	♈	17 48	-	196 25
	14 deg. So. def. -	♏	22 37	-	324 59

PROB. IV.

How to rectify the Celestial Globe for any Day.

Slide the brass *Meridian* in the Notches of the wooden Frame upwards or downwards, until the

the *Horizon* cut the *Latitude* of the Place, so shall the Pole be elevated above the *Horizon* the Quantity of the *Latitude*.

Bring the *Sun's* Place in the *Ecliptic* to the brass *Meridian*, and there stay the *Globe*.

Set the *Index* of the *Hour-Circle* to the uppermost 12, that is, to 12 at Noon.

Then screw the *Quadrant of Altitude* to the *Zenith*, that is, to the Degree of *Latitude*; and thus will the *Globe* be rectified for Use.

P R O B. V.

To find the Time of Sun-Rising and Setting any Day of the Year.

Rectify the *Globe* to the given *Latitude*, and to the given Time.

Move the *Globe* eastward until the *Sun's* Place in the *Ecliptic* lie just in the *Horizon*; then will the *Index* point out on the Dial-plate the Time of Sun-rising.

Again, Turn the *Globe* westward, until the *Sun's* Place in the *Ecliptic* meet the *Horizon* in the West; and then the *Index* will shew the Time of Sun-setting.

And thus it will be found that on the 10th of *January*, in the Latitude of *Philadelphia*, the *Sun* rises at 19 Minutes after Seven, and sets at 41 Minutes after Four.

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More EXAMPLES for Practice.

		Sun-rise.		Sun-set.	
		ho. m.		ho. m.	
May	1 - - -	5	8 - - -	6	52
July	15 - - -	4	43 - - -	7	17
Sept.	29 - - -	6	8 - - -	5	52
Nov.	12 - - -	7	2 - - -	4	58

P R O B. VI.

The Latitude and Day of the Month given, to find the Length of the Day and Night.

Rectify the *Globe*. Then bring the *Sun's* Place in the *Ecliptic* to the western Side of the *Horizon*, and mark on the Dial-plate the Time of *Sun-setting*.

Then turn the *Globe* still westward, until the *Sun's* Place in the *Ecliptic* appears on the eastern Side of the *Horizon*, and mark on the Dial-plate the Time of *Sun-rising*.

And the Hours and Minutes which the *Index* passes over from *Sun-set* to *Sun-rise*, shall be the nocturnal Arch, or Length of the *Night*.

Again, Move the *Globe* still westward, until the *Sun's* Place touch the *Horizon* on the West Side of the *Meridian*, or until the *Index* points to the Time of setting, so shall the Hours and Minutes passed over by the *Index* from *Sun-rising* to *Sun-setting*, be the Measure of the diurnal Arch, or Length of the *Day*.

N. B.

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N. B. That twice the Time of *Sun*-rising is the Length of the *Night*, and twice the Time of *Sun*-setting is the Length of the *Day*.

And after this manner it will be found that the Length of the *Day* in the Latitude of *Philadelphia* on *January* the 10th is 9 Hours 22 Minutes, and the Length of the *Night* 14 Hours 38 Minutes.

Take the following Examples for every 10 Degrees of *Latitude*, on the 12th of *April*,

	Night.		Day.	
	ho. m.		ho. m.	
North Lat. 10 Deg. - -	11	48	- -	12 12
20 Deg. - -	11	34	- -	12 26
30 Deg. - -	11	20	- -	12 40
40 Deg. - -	11	2	- -	12 58
50 Deg. - -	10	36	- -	13 24
60 Deg. - -	9	58	- -	14 2
70 Deg. - -	8	42	- -	15 18
80 Deg. - -	4	2	- -	19 58

And contrarywise in South *Latitude*.

P R O B. VII.

The Latitude of a Place, and the Day of the Month given, to find the Sun's Amplitude.

Rectify the *Globe* to the *Latitude* and Place of the *Sun*.

Move the *Globe* eastward, until the *Sun's* Place lie even with the *Horizon*, then the Degree of the *Horizon* against the Place of the *Sun*,

C 2

shall

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shall be the Sun's *Amplitude*, towards the North or South at rising.

And if the Place of the *Sun* be brought to the western Side of the *Horizon*, the Degree of the *Horizon* cut by the *Ecliptic*, will shew the *Sun's Amplitude* at setting, either North or South, and will be the same as before.

Thus the Sun's *Amplitude*, on *May* the 20th, for the *Latitude* of 40 Degrees, will be found to be East 26 Degrees 31 Minutes North; and at setting, West 26 Degrees 31 Min. northerly.

Also on *October* the 11th, in the *Latitude* of 40 Degrees, the *Amplitude* of the *Sun* at rising will be found East 9 Degrees 14 Minutes South, and at setting, West 9 Degrees 14 Min. South.

More EXAMPLES for the 29th of *April*.

Lat. No.	10 deg.	Amp. at rising.		Amp. at setting.	
		- E.	N. - W.	-	N.
	20 deg.	- 15 27	-	15 27	
	30 deg.	- 16 48	-	16 48	
	40 deg.	- 19 5	-	19 5	
	50 deg.	- 22 56	-	22 56	
	60 deg.	- 30 3	-	30 3	
	70 deg.	- 47 4	-	47 4	
	75 deg.	- 75 20	-	75 20	

And in South Latitude the *Amplitude* will be the very same, only of a contrary Denomination.

P R O B.

P R O B. VIII.

The Latitude and Day of the Month given, to find the Sun's Oblique Ascension, and Oblique Descension.

Rectify the *Globe* to the *Latitude* and *Sun's Place*.

Then bring the *Place* of the *Sun* to the *East Side* of the *Horizon*, and letting the *Globe* rest, see what *Degree* of the *Equinoctial* is cut by the *Horizon*, and that is the *Sun's Oblique Ascension*.

Then turn the *Globe* westward, until the *Sun's Place* lie even with the *West Side* of the *Horizon*, and the *Degree* of the *Equinoctial* descending, is the *Sun's Oblique Descension*.

Thus, in the *Latitude* of 40 Degrees North, and on the 17th of *April*, the *Oblique Ascension* of the *Sun* will be found to be 16 Degrees 27 Minutes, and the *Oblique Descension* 34 Degrees 29 Minutes.

More EXAMPLES for Practice.

Latitude 40 Degrees North,

			D.	M.		D.	M.
May	25	- Ob. Af.	43	22	- Ob. Def.	80	58
July	12	- -	91	46	- -	131	24
Sept.	30	- -	189	8	- -	184	16
Nov.	18	- -	251	4	- -	216	48
Jan.	3	- -	304	48	- -	263	24
March	11	- -	354	45	- -	348	45

C 3

And

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And if the *Latitude* were South, the *Oblique Ascensions* above, would be the *Oblique Descensions*, and the contrary.

P R O B. IX.

The Latitude and Day of the Month given, to find the Sun's Altitude and Azimuth at any Hour of the Day.

Rectify the *Globe* by PROB. IV.

Move the *Globe* easterly or westerly, as Occasion requires, until the *Index* points to the given Hour.

Then keeping the *Globe* still, bring the graduated Edge of the *Quadrant of Altitude* to the Sun's Place in the *Ecliptic*, and there let it rest.

See what Degree of the *Quadrant of Altitude* lies even with the Sun's Place in the *Ecliptic*; for that is the Sun's *Altitude* for the given Time.

And if you count the Number of Degrees on the *Horizon*, between the North or South Points and the graduated Edge of the *Quadrant of Altitude*, you will have the Sun's *Azimuth*.

Thus, the 20th of *January*, and in the Latitude of *Philadelphia*, the Sun's *Altitude* will be found at Nine in the Morning, or at Three in the Afternoon, 16 Degrees 49 Minutes, and the Sun's *Azimuth* from the South 43 Degrees 58 Minutes. And at Ten and Two o'Clock, the *Altitude* is 23 Degrees 48 Minutes, and *Azimuth* 30 Degrees 55 Minutes.

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More EXAMPLES for the Learner's Exercise, fitted to the *Latitude* of 40 Degrees North, and the Hours of Nine and Three.

		D. M.		D. M.	
Febr.	4 - Sun's Alt.	20	6 - Azim.	46	22 from So.
March	5 - -	28	8 - -	52	53
April	10 - -	38	43 - -	63	52
May	4 - -	44	15 - -	71	35
June	21 - -	48	51 - -	80	15

And at Six o'Clock,

July	12 - -	13	56 - -	73	7 from No.
August	15 - -	8	57 - -	79	13

P R O B. X.

The Latitude, Day of the Month, and Azimuth of the Sun being given, to find the Sun's Altitude, and the Time of the Day.

Rectify the *Globe* by PROB. IV.

Count the *Azimuth* of the *Sun* on the wooden *Horizon*, to which bring the *Quadrant of Altitude*, and there keep it.

Move the *Globe* until the *Sun's* Place in the *Ecliptic* lie even with the graduated Edge of the *Quadrant of Altitude*, and then keep all still.

Then shall the Degree of the *Quadrant* cut by the *Ecliptic*, be the *Sun's Altitude*, and the *Index* of the *Hour-Circle* will point to the Time of the *Day*.

Thus, in the *Latitude* of 40 Degrees, and on the twenty-first of *January*, the *Sun* being

C 4

South

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South South East, his *Altitude* will be found 26 Degrees 58 Minutes, and the Time of the Day 35 Minutes after Ten in the Morning.

In the *Latitude* of 50 Degrees North, and on the 17th of *March*, the *Sun* will be found to come South-West at 32 Minutes after Two, and the *Sun's Altitude* will be 29 Degrees 11 Minutes.

In the *Latitude* of 60 Degrees North, the *Sun* in the *Tropic of Cancer*, he will be North-East at 21 Minutes past Three in the Morning, and his *Altitude* 3 Degrees 39 Minutes.

In the *Latitude* of 30 Degrees South, the *Sun* in the *Tropic of Capricorn*, the *Sun* will be North-West at 28 Minutes after Twelve, and his *Altitude* 81 Degrees 2 Minutes.

And at *Philadelphia*, the *Sun* being in the *Tropic of Cancer*, will come due East at 5 Min. after Eight, due West at 55 Min. past Three, and his *Altitude* will be 38 Deg. 19 Min.

P R O B. XI.

The Latitude and Day of the Month given, together with the Sun's Altitude, to find the Time of the Day, and Azimuth of the Sun.

The *Globe* being rectified by PROB. IV. move the *Globe* and *Quadrant of Altitude*, until the *Sun's Place* in the *Ecliptic* meet with the given *Altitude* on the *Quadrant of Altitude*, and there let all rest.

See

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See what Hour and Minute the *Index* points ; for that is the Time of the *Day*.

And the Arch of the *Horizon* contained between the graduated Edge of the *Quadrant* of *Altitude* and the North or South Points of the *Horizon*, is the Sun's *Azimuth*.

Thus, in the *Latitude* of 40 Degrees, on the 8th of *July*, I observed the Sun's *Altitude* to be 37 Deg. 30 Min. Then, by the foregoing Directions, I find the Time of the Day either 4 Minutes past Eight, or 46 Min. after Three, and the Sun's *Azimuth* from the North 96 Deg. 0 Min.

And in the *Latitude* of 20 Deg. South, on the first Day of *December*, when the Sun's *Altitude* is 29 Deg. 20 Min. the Time of the Day will be found to be either 38 Min. after Seven in the Morning, or 22 Min. after Four in the Afternoon, and the Sun's *Azimuth* from the South 75 Deg. 34 Min.

N. B. In operating by the *Globe* for this and other Problems, if the Sun's *Declination* be given instead of the Sun's *Place*, or Day of the *Month*, you may bring the *Equinoctial Colure* to the brass *Meridian*, and the *Index* to 12 o'Clock; which rectifies the *Globe* when the *Declination* is given. Then shall the Degree of *Declination* counted on the *Equinoctial Colure*, perform the same Office as the Degree of the *Ecliptic* itself would do.

P R O B. XII.

Having the Latitude, the Altitude of the Sun and his Azimuth given, to find the Day of the Month, and Time of the Day.

Let the *Globe* be rectified to the *Latitude* and the *Quadrant of Altitude* screwed to the *Zenith*.

Bring the graduated Edge of the *Quadrant of Altitude* to the given *Azimuth* on the *Horizon*, and there keep it.

Turn the *Globe* about, until the *Ecliptic* cut the *Quadrant* in the given *Altitude*, and the Degree of the *Ecliptic* which lieth under the *Sun's Altitude*, shall be the *Sun's Place*.

Keeping the *Quadrant of Altitude* still, move the *Globe* until the *Sun's Place* come to the *Meridian*, then set the *Index* of the *Hour-Circle* to 12 at Noon.

Then turn the *Sun's Place* back again to the *Quadrant of Altitude*, and the *Index* will point to the given Hour.

Lastly seek the *Sun's Place* on the wooden Frame, and against it stands the Day of the Month.

Thus, at *Philadelphia*, when the *Sun's Altitude* is 45 Degrees, and his *Azimuth* South 60 Degrees West, his *Place* will be $\sphericalangle$ 27 Degrees 27 Minutes, or $\cap$ 2 Degrees 33 Minutes, the Day of the *Year* will be the 17th
of

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April, or the 25th of *August*, at 34 Minutes after Two.

And in the *Latitude* of 50 Degrees North, if the *Sun's Altitude* be 10 Degrees, and his *Azimuth* East North East, the *Sun's Place* in the *Ecliptic* will be found to be Π 10 Deg. 18 Minutes, or $\S$ 19 Deg. 42 Minutes, and the Time June the first and *July* 12, at 16 Minutes past five in the Morning.

Also in the *Latitude* of 30 Degrees South, if the *Sun* be 75 Degrees high, and bear North East by North, his *Place* in the *Ecliptic* will be Λ 18 Deg. 38 Minutes, and Ξ 11 Deg. 22 Minutes, to which answers the 11th of *November* and thirty-first of *January*, at 25 Minutes after eleven o'Clock.

P R O B. XIII.

How to find the Right Ascension and Declination of any Fixed Star.

Bring the *Star*, whose *Right Ascension* and *Declination* you want to know, to the brass *Meridian*, and there keep it.

The Degree of the *Meridian* directly over the Center of the *Star*, is the *Declination*, either North or South.

And the Degree of the *Equinoctial* cut by the brass *Meridian*, is the *Star's Right Ascension*.

EXAM-

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EXAMPLES.

	R. Ascen.		Dec.		
	deg.	m.	deg.	m.	
Pole Star - - - - -	10	32	87	58	No.
Pleiades, or Seven Stars - -	52	48	23	44	No.
Aldebaran, or Bull's Eye -	65	23	15	59	No.
Capella, or the Goat - -	74	33	45	44	No.
Regel, or Orion's bright Foot	75	38	8	31	So.
Orion's right Shoulder - -	85	24	7	20	No.
Syrius, or the Great Dog -	98	33	16	22	So.
Castor, or northermost Twin	109	39	32	25	No.
Procyon, or the Little Dog -	111	33	5	52	No.
Pollux, or southermost Twin	112	30	28	37	No.
Hydra's Heart - - - -	138	49	7	35	So.
Regulus, or Lion's Heart -	148	45	13	10	No.
The northermost of the Pointers	162	2	63	6	No.
Deneb, or Lion's Tail - -	174	5	15	58	No.
Alioth - - - - -	190	47	57	20	No.
Cor Caroli - - - - -	191	6	39	40	No.
Virgin's Spike - - - -	198	1	9	51	So.
Arcturus - - - - -	211	5	20	32	No.
Southern Ballance - - -	219	17	14	59	So.
Antares, or Scorpion's Heart	243	32	25	51	So.
Northern Ballance - - -	225	54	8	27	So.
Lyrae, or the Harp - - -	277	6	38	34	No.
Vulture, or Eagle's Heart -	294	37	8	13	No.
Fomahant, or southern Fish -	340	55	30	56	So.
Marchab, or Pegafus's Wing -	343	4	13	51	No.
Andromeda's Head - - -	358	52	27	42	No.
Algenib, or End of Pegaf. Wing	0	5	13	47	No.

Computed to the Beginning of the Year 1750.

P R O B. XIV.

How to find the Longitude and Latitude of any Fixed Star on the Globe.

Move the *Globe* until the *Solstitial Colure* comes to the brass *Meridian*, and there let it rest.

Screw the *Quadrant of Altitude* just over the
Pole.

The USE of the Celestial GLOBE. 45

ole of the *Ecliptic*, which will be 23 Degrees and a half from the *Pole* of the World.

Bring the graduated Edge of the *Quadrant* of *Altitude* to the *Star* whose *Longitude* and *Latitude* you seek, the Degree of the *Quadrant* lying even with the Center of the said *Star*, shall be its *Latitude*.

And the Degree of the *Ecliptic* cut by the *Quadrant* of *Altitude*, will shew its *Longitude*.

EXAMPLES.

	Long.		Lat.		
	deg. m.		deg. m.		
ble Star - - - - -	π	25 5	66 4	No.	
eiades, or Seven Stars - -	8	26 17	4 30	No.	
debaran, or Bull's Eye -	π	6 17	5 30	So.	
apella, or the Goat - -	π	18 22	22 52	No.	
egel, or Orion's bright Foot	π	13 20	31 10	So.	
Orion's right Shoulder - -	π	25 15	16 4	So.	
rius, or the Great Dog -	☐	10 39	39 32	So.	
astor, or northermost Twin	☐	16 45	10 4	No.	
rocyon, or the Little Dog -	☐	22 21	15 58	So.	
ollux, or southermost Twin	☐	19 46	6 39	No.	
ydra's Heart - - - - -	♏	23 48	22 25	So.	
egulus, or the Lion's Heart	♌	26 21	0 27	No.	
The northermost of the Pointers	♌	11 40	49 40	No.	
eneb, or the Lion's Tail	♏	18 9	12 17	No.	
lioth - - - - -	♏	5 23	54 20	No.	
or Caroli - - - - -	♏	21 3	40 7	No.	
irgin's Spike - - - - -	♌	20 21	2 2	So.	
ercturus - - - - -	♌	20 44	30 57	No.	
outhern Ballance - - -	♏	11 37	0 23	No.	
ntares, or Scorpion's Heart	♏	6 18	4 31	So.	
orthern Ballance - - -	♏	15 54	8 32	No.	
yræ, or the Harp - - -	♏	11 47	61 46	No.	
ulture, or the Eagle's Heart	♏	28 13	29 19	No.	
omahant, or southern Fish -	♏	0 19	21 5	So.	
Marchab, or Pegasus's Wing -	♏	19 59	19 25	No.	
ndromeda's Head - - -	♏	10 49	25 41	No.	
ugenib, or End of Pegaf. Wing	♏	5 40	12 35	No.	

Computed to the Beginning of the Year 1750.

TRIGONOMETRY.

Right angled Plain Triangles.

CASE I.

Given the Base and the Angles, to find the Hypothenuse and Perpendicular.

FIRST, As the Complement Sine of the Angle at the Base is to the Base, so is Radius to the Hypothenuse.

Secondly, As the Complement Sine of the Angle at the Base is to the Base, so is the Sine of the Angle at the Base to the Perpendicular.

CASE II.

Given the Hypothenuse and the Angles, to find the Base and Perpendicular.

First, As Radius is to the Hypothenuse, so is the Sine of the Angle at the Perpendicular to the Base.

Secondly, As the Radius is to the Hypothenuse, so is the Sine of the Angle at the Base to the Perpendicular.

CASE

C A S E III.

Given the Hypothenuſe and the Baſe, to find the Angles and the Perpendicular.

First, As the Hypothenuſe is to Radius, ſo is the Baſe to the Sine of the Angle at the Perpendicular.

Secondly, As Radius is to the Hypothenuſe, ſo the Complement Sine of the Angle at the Perpendicular; or ſo is the Sine of the Angle at the Baſe to the Perpendicular.

C A S E IV.

Given the Baſe and Perpendicular, to find the Hypothenuſe and the Angles.

First, As the Baſe is to the Perpendicular, ſo Radius to the Tangent of the Angle at the Baſe.

Secondly, As the Sine of the Angle at the Baſe to the Perpendicular, ſo is Radius to the Hypothenuſe.

Note, The two acute Angles taken together always make 90 Degrees, ſo that when one of them is known, the other is alſo known: And the Complement Sine of one acute Angle and the Sine of the other is one and the ſame Thing.

Oblique

Oblique angled Plain Triangles.

CASE I.

Given the Angles and one Side, to find the other two Sides.

As the Sine of the *Angle* opposite to the given *Side*, is to the given *Side*, so is the Sine of either of the other two *Angles* to the *Side* opposite thereto. For in all Plain Triangles the *Sides* are in direct Proportion to the Sines of their opposite *Angles*, and the contrary.

CASE II.

Given two Sides, and an Angle opposite to one of them, to find the other two Angles and third Side.

First, As the *Side* opposite to the given *Angle* is to the Sine of the given *Angle*, so is the other given *Side* to the Sine of its opposite *Angle*.

Then add the two known *Angles* together, and subtract their Sum from 180 Degrees, and what remains will be the third *Angle*. For all three make 180 Degrees.

Secondly, As the Sine of the given *Angle* is to its opposite *Side*, so is the Sine of the third *Angle* to the *Side* required.

Note,

TRIGONOMETRY. 49

Note, If the given *Angle* be acute, and it be opposite to the lesser given *Side*, it will be doubtful whether the second *Angle* found in the first Operation, be acute or obtuse. Therefore the Quality of that *Angle* should be always given, otherwise the required *Side* cannot absolutely be determined.

CASE III.

Given two Sides, and the contained Angle, to find the other two Angles, and third Side.

First, Subtract the given *Angle* from 180 Degrees, and what remains is the Sum of the unknown *Angles*.

Then, as the Sum of the two given *Sides* is to their Difference, so is the Tangent of half the Sum of the unknown *Angles* to the Tangent of half their Difference.

Then the half Difference added to the half Sum, gives the greatest of the two unknown *Angles*; but if the half Difference be subtracted, it gives the least.

Secondly, As the Sine of either of the two *Angles* now found is to its opposite *Side*, so is the Sine of the given *Angle* to the *Side* required.

CASE IV.

Given the three Sides, to find the Angles.

First, Let a *Perpendicular* fall on the *Base*, or longest *Side* from the opposite *Angle*. This
D
will

will divide the *Base* into two Parts or *Segments*.
Then say,

As the *Base* is to the Sum of the two shortest *Sides*, so is the Difference of the two lesser *Sides* to the Difference of the *Segments* of the *Base*.

Then half this Difference added to half the *Base*, gives the greater *Segment*; but subtracted leaves the lesser.

Secondly, As either of the two lesser *Sides* is to *Radius*, so is the adjacent *Segment* to the Complement Sine of the contained *Angle*.

Or, as either *Segment* of the *Base* is to *Radius*, so is the *Side* adjacent to the Secant of the contained *Angle*.

Right angled Spherical Triangles.

CASE I.

Given the Hypothemuse and one of the Oblique Angles, to find

*The Leg opposite to the given Angle,
The Leg adjacent to the given Angle,
The other Oblique Angle.*

First, As *Radius* is to the Sine of the *Hypothemuse*, so is the Sine of the given *Angle* to the Sine of the *Leg* opposite to the given *Angle*. Which is less than 90 Degrees, if the given *Angle* be acute, otherwise it is greater.

Secondly

Secondly, As *Radius* is to Tangent of the *Hypothenuſe*, ſo is the Complement Sine of the given *Angle* to the Tangent of the *Leg* adjacent. Which is leſs than 90 Degrees, when the *Hypothenuſe* and given *Angle* are both more or leſs than 90 Degrees, otherwiſe it is greater.

Thirdly, As *Radius* is to the Tangent of the given *Angle*, ſo is the Complement Sine of the *Hypothenuſe* to the Complement Tangent of the other oblique *Angle*. Which is acute, when the given Things are both more or both leſs than 90 Degrees, otherwiſe it is obtuſe.

C A S E II.

Given the *Hypothenuſe* and one of the *Legs*,
to find

The *Angle* oppoſite to the given *Leg*,
The contained *Angle*,
The other *Leg*.

First, As the Sine of the *Hypothenuſe* is to the Sine of the given *Leg*, ſo is *Radius* to the Sine of the oppoſite *Angle*. Which is acute, when the given *Leg* is leſs than 90 Degrees, otherwiſe it is obtuſe.

Secondly, As *Radius* is to the Tangent of the given *Leg*, ſo is the Complement Tangent of the *Hypothenuſe* to the Complement Sine of the contained *Angle*. Which is acute, when the *Hypothenuſe* and given *Leg* are both more or

both less than a Quadrant, otherwise it is obtuse.

Thirdly, As the Complement Sine of the given *Leg* is to the Complement Sine of the *Hypothenuse*, so is *Radius* to the Complement Sine of the other *Leg*. Which is less than a Quadrant, when the *Hypothenuse* and given *Leg* are both more or both less than a Quadrant, otherwise it is greater.

C A S E III.

Given one Leg and the adjacent Angle, to find

The Angle opposite to the given Leg,
The other Leg,
The Hypothenuse.

First, As *Radius* is to the Sine of the given *Angle*, so is the Complement Sine of the given *Leg* to the Complement Sine of its opposite *Angle*. Which is acute, when the given *Leg* is less than a Quadrant, otherwise it is obtuse.

Secondly, As *Radius* is to the Tangent of the given *Angle*, so is the Sine of the given *Leg* to the Tangent of the other *Leg*. Which, if the given *Angle* be acute, is less than a Quadrant, otherwise it is greater.

Thirdly, As *Radius* is to the Complement Tangent of the given *Leg*, so is the Complement Sine of the given *Angle* to the Complement Tangent of the *Hypothenuse*. Which is less than a Quadrant, when the given Things are

are both more or both less than 90 Degrees, otherwise it is greater.

C A S E IV.

Given one Leg and its opposite Angle, to find

The other Leg,

The Hypothenufe,

The other Angle.

First, As *Radius* is to the Tangent of the given *Leg*, so is the Complement Tangent of the given *Angle* to the Sine of the *Leg* required. Which, if the unknown *Angle* be acute, or if the *Hypothenufe* and given *Leg* be both more or both less than Quadrants, is less than a Quadrant, otherwise greater.

Secondly, As the Sine of the given *Angle* is to the Sine of the given *Leg*, so is *Radius* to the Sine of the *Hypothenufe*. Which is less than a Quadrant, when both *Legs*, or both the oblique *Angles*, be of the same Kind, otherwise the *Hypothenufe* is greater than a Quadrant.

Thirdly, As the Complement Sine of the given *Leg* is to the Complement Sine of the given *Angle*, so is *Radius* to the Sine of the *Angle* required. Which is acute, if the *Leg* adjacent to the given *Angle* be less than a Quadrant, otherwise it is obtuse.

CASE V.

Given the two Legs, to find

The Angles,

The Hypothenufe.

First, As *Radius* is to the Complement Tangent of one of the *Legs*, so is the Sine of the other *Leg* to the Complement Tangent of the *Angle* opposite to the first *Leg*. Which is acute, if its opposite *Side* be less than a Quadrant, otherwise it is obtuse.

Secondly, As *Radius* is to the Complement Sine of one of the *Legs*, so is Complement Sine of the other *Leg* to Complement Sine of the *Hypothenufe*. And if the *Legs* are both less or both more than a Quadrant, the *Hypothenufe* is less than a Quadrant, otherwise it is greater.

CASE VI.

Given both the oblique Angles, to find

The Legs,

The Hypothenufe.

First, As the Sine of one *Angle* is to *Radius*, so is the Complement Sine of the other *Angle* to the Complement Sine of the *Leg* adjacent to the first *Angle*. Which is less than 90 Degrees, if its opposite *Angle* be acute, else it is more than 90 Degrees.

Secondly, As *Radius* is to the Complement Tangent of one of the oblique *Angles*, so is the
the

the Complement Tangent of the other to the Complement Sine of the *Hypothenuſe*. Which is leſs than a Quadrant, if the oblique *Angles* be both acute or both obtuſe, otherwiſe it is greater than a Quadrant.

Oblique angled Spherical Triangles.

C A S E I.

Given two Sides, and an Angle opposite to one of them, to find

*The Angle opposite to the other given Side,
The contained Angle,
The third Side.*

First, As the Sine of the *Side* opposite to the given *Angle* is to the Sine of the given *Angle*, ſo is the Sine of the other given *Side* to the Sine of its opposite *Angle*.

Secondly, As the Sine of half the Difference of the two given *Sides* is to the Sine of half their Sum, ſo is the Tangent of half the Difference of the known *Angles* to the Complement Tangent of half the contained *Angle*.

Thirdly, As the Sine of half the Difference of the *Angles* opposite to the given *Sides* is to the Sine of half their Sum, ſo is the Tangent of half the Difference of the given *Sides* to the Tangent of half the third *Side*.

Note, In this and the following *Case*, besides the three given Things, the Quality of a fourth should be known, otherwise it will be uncertain whether the required Sides or Angles are more or less than 90 Degrees.

C A S E I I

Given two Angles, and a Side opposite to one of them, to find

*The Side opposite to the other given Angle,
The Side opposite to the unknown Angle,
The third Angle.*

First, As the Sine of the *Angle* opposite to the given *Side* is to the Sine of the given *Side*, so is the Sine of the other given *Angle* to the Sine of its opposite *Side*.

Secondly, As the Sine of half the Difference of the *Angles* is to the Sine of half their Sum, so is the Tangent of half the Difference of the known *Sides* to the Tangent of half the third *Side*, or *Side* opposite to the unknown *Angle*.

Thirdly, As the Sine of half the Difference of the two first *Sides* is to the Sine of half their Sum, so is the Tangent of half the Difference of the given *Angles* to the Complement Tangent of half the third *Angle*.

CASE III.

*Given two Sides, and the contained Angle,
to find*

*Either of the opposite Angles,
The third Side.*

First, As the Sine of half the Sum of the two given *Sides* is to the Sine of half their Difference, so is the Complement Tangent of the contained *Angle* to the Tangent of half the Difference of the unknown *Angles*.

Then, As the Complement Sine of half the Sum of the unknown *Angles* is to the Complement Sine of half their Difference, so is the Complement Tangent of half the contained *Angle* to the Tangent of half the Sum of the unknown *Angles*.

The half Difference added to the half Sum gives the greatest of the two unknown *Angles*; but subtracted, leaves the least.

Note, If the Sum of the two given *Sides* be greater than 180 Degrees, subtract each *Side* from 180 Degrees, and operate with the Remainders as before, then shall the *Angles* produced be the Supplements of the required *Angles* to 180 Degrees.

Secondly, As *Radius* is to the Complement Sine of the given *Angle*, so is the Tangent of the lesser given *Side* to the Tangent of a *fourth Arch*.

This

This must be subtracted from the greater given *Side*, if the given *Angle* be acute; otherwise from what it wants of 180 Degrees; and what remains, is a *fifth Arch*.

Then, As the Complement Sine of the *fourth Arch* is to the Complement Sine of the *fifth Arch*, so is the Complement Sine of the lesser given *Side* to the Complement Sine of the third *Side*. Which is less than a Quadrant, if the contained Angle and *fifth Arch* are both more or both less than 90 Degrees, otherwise the third *Side* is greater than a Quadrant.

CASE IV.

*Given two Angles, and a Side between them,
to find*

*Either of the other Sides,
The third Angle.*

First, As the Sine of half the Sum of the given *Angles* is to the Sine of half their Difference, so is the Tangent of half the given *Side* to the Tangent of half the Difference of the other two *Sides*.

Again, As the Complement Sine of the half Sum of the given *Angles* is to the Complement Sine of half their Difference, so is the Tangent of half the given *Side* to the Tangent of half the Sum of the other two *Sides*.

To

To which the half Difference of the *Sides* being added, gives the greater; but subtracted, leaves the lesser.

Note, If the Sum of the two given *Angles* exceed 180 Degrees, subtract each of them from 180 Degrees, and work with the Remainders as above, so shall the last Sum and Difference, if subtracted from 180 Degrees, give the *Sides* sought.

Secondly, As *Radius* is to the Complement Sine of the given *Side*, so is the Tangent of the lesser given *Angle* to the Tangent of a *fourth Arch*.

This must be subtracted from the greater given *Angle*, if the given *Side* be more than a Quadrant; but if less, from what it wants of 180 Degrees; and what remains will be a *fifth Arch*.

Then, As the Complement Sine of the *fourth Arch* is to the Complement Sine of the *fifth Arch*, so is the Complement Sine of the lesser given *Angle* to the Complement Sine of the *Angle* required.

And this *Angle* is acute, when the given *Side* and *fifth Arch* are both more or both less than 90 Degrees, otherwise it is obtuse.

CASE V.

Given the three Sides, to find an Angle.

Take the Complement Arithmetical of the Logarithm Sines of the two *Sides* containing the *Angle*.

Angle required, also the *Logarithm Sine* of half the Sum of the three *Sides*, and the *Logarithm Sine* of the Difference of the said half Sum from the *Side* opposite to the *Angle* sought; then add these four *Logarithms* together, and half that Sum shall be the Complement Sine of half the required *Angle*.

CASE VI.

Given the three Angles, to find a Side.

To work this *Case*, take the Supplement of the greatest given *Angle* to 180 Degrees, instead of the *Angle* itself.

Then, to the Complement Arithmetical of the *Logarithm Sines* of the two *Angles* next the *Side* required, add the *Logarithm Sine* of half the Sum of the three *Angles*, also the *Logarithm Sine* of the Difference of the said half Sum from the *Angle* opposite to the required *Side*: And half the Sum of these four *Logarithms* is the Complement Sine of half the required *Side*. Except when the greatest *Side* is required, the Operation produces its Supplement to 180 Degrees.

The E N D.

THE foregoing Rules in Plain and Spherical *Triangles*, are added for the Use of young Practitioners in the *Mathematics*, whereby they may immediately find a *Canon* to resolve the *Case* in question, without the Trouble of searching in larger Volumes. But from what Principles these *Canons* are deduced, and how all the Variety of *Cases* both in Plain and Spherical *Triangles* are constructed and measured, which is the most beautiful Part of the *Science*, is taught at large by the AUTHOR.

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June, 1954

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